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NOTES ON PRECAUTIONS TO BE TAKEN WHEN DRILLING OIL OR GAS WELLS THROUGH WORKABLE COAL BEDS OR THROUGH MINE WORKINGS

BY

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NOTES ON PRECAUTIONS TO BE TAKEN WHEN DRILLING OIL OR GAS WELLS THROUGH WORKABLE COAL BEDS OR THROUGH MINE WORKINGS[1]

By C. A. Herbert[2]

The added hazards to mining incident to oil and gas wells penetrating the coal measures in proximity to mine workings, have long been recognized in those fields where the extraction of oil, gas, and coal, has been in progress for a number of years. The history of these fields is replete with stories of serious mine fires, explosions, and miraculous escapes from both fires and explosions due to either oil or gas finding its way into the mine workings through the strata, or by mining into an unknown or uncharted and abandoned oil or gas well that had not been properly plugged.

The Director of the Bureau of Mines, in response to numerous requests from coal operators and oil and gas operators, called a meeting in 1913 to discuss necessary precationary measures to take when drilling oil or gas wells through workable coal beds and to try, if possible, to formulate a set of regulations that might serve as a guide to those persons preparing regulations covering the drilling of oil and gas wells in the various coal producing States.

This meeting was attended by representatives of the coal, oil, and gas industries, State geologists, State mine inspectors, and representatives of the Bureau of Mines.

A committee was appointed to prepare a set of regulations, which was later published as U.S.Bureau of Mines Technical Paper 53; the discussions and results of the meeting werepublished as U. S. Bureau of Mines Bulletin 65.

Later, the American Institute of Mining and Metallurgical Engineers appointed a committee to draft a model law for the use of the legislature of any State concerned. This committee made its report on April 27, 1928.

Several of the coal mining States now have more or less comprehensive regulations governing the drilling of oil or gas wells through workable coal beds, others have regulations that are inadequate, while some have no regulations. The State of West Virginia recently enacted a law containing regulations which are the result of a comprehensive and careful study of the problem. The drilling and mining requirements have been patterned

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1 - The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6195."

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largely after the report of the committee appointed by the American Institute of Mining and Metallurgical Engineers.

Recently, inquiries have come into the bureau from coal-mine operators in States where mining operations of coal beds are not adequately protected by existing regulations, and it is in response to these inquiries that these notes have been prepared.

LOCATION OF WELLS

Coal companies who were fortunate enough to have acquired all mineral rights, including oil and gas, by purchase or lease, have been in a position to demand proper protection by those drilling the wells. However, in many instances the original owner of the land disposed of the coal and of the oil and gas rights separately. Wells were drilled, later abandoned without being plugged, and no record made of their location before the coal rights were sold, or at least before the hazard of uncharted or unprotected wells was realized by the coal companies.

The exact location of all oil and gas wells penetrating workable coal beds is of first importance, and a careful survey should be made to determine the location of the wells with respect to boundaries of the tract of land or Government survey corners. A map showing their location should be prepared, on which the exact distance and direction of the wells from the reference corners is shown. The names of the adjoining property owners should also be shown, as well as any other information that might assist in the relocation of the wells. It is also desirable that a careful log of the strata passed through in drilling the wells should be kept and should be shown on the map. A copy of the map should be filed as a record at the county recorder's office, and also with the chief mine inspector. When the coal rights and oil and gas rights are separately owned or leased, a copy of the map should be given to the coal operator, who should accurately locate the wells on both his property and mine maps.

Where it is possible to do so, the wells should be so located as to conform as nearly as possible to a definitely projected plan for development of the coal beds; the wells should be drilled through permanent pillars, or located where pillars may be left around them with as little loss of coal and cause as little inconvenience to the operation of the mine as possible. In no case should a well be located within less than 15 feet of any underground haulageway, airway, or traveling way, in so far as this is possible.

It must be recognized that drill holes may deviate materially from the vertical, hence it must not be taken for granted that the intersection of the drill hole with the coal bed will be vertically beneath the top of the hole. The provision of a pillar of coal to protect the drill hole from distortion by movement of the overlying strata after coal has been extracted and to protect the mine from leaking gas or oil must allow for a variation of several feet (5 to 25 or more) in the estimated point of intersection of the well with the coal bed. Holes drilled with cable tools are likely to be more nearly vertical than rotary-drilled holes, especially if the cover above the coal bed is shallow. In deeper wells, a deviation of one degree from the vertical will cause a deviation of 17½ feet horizontally at a depth of 1,000 feet. Many mining companies have found it necessary to survey drill holes to determine the exact location of the bottom of the holes. Where coal beds

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have thick cover (anything over 1,000 feet) surveying of drill holes should be considered necessary in connection with any proposed planning to protect mine workings.

SIZE OF PILLAR AROUND WELL

Since it has been determined that a coal pillar surrounding an oil or gas well can not be depended upon to keep either the oil or gas from finding its way into the mine workings, either through the coal or through the overlying or underlying strata, essentially its only function is to protect the well from damage due to possible movement of the strata, resulting from the extraction of the coal. Hence, the size of the pillar to be left will be governed by the depth and thickness of the coal and by the character of the overlying and underlying strata. A pillar of over 100 feet in diameter would seldom be necessary, while, on the other hand, one of less than 50 feet in diameter is not advisable. Experience in the particular field where drilling is being done, taking into consideration the thickness of the coal bed and of the overlying strata, would perhaps be the best guide as to the proper diameter of the pillar.

DRILLING WELLS AND PROTECTING WORKABLE COAL BEDS

The report of the committee of 1913, published as U. S. Bureau of Mines Technical Paper 53 previously referred to, recommends that where the drill hole penetrates one or more workable coal beds, the hole should be drilled 6 inches greater in diameter than the largest casing to be used, should be at least 30 feet below the lowest workable coal bed, and the space between the casing and the wall of the well should be filled with cement mortar or puddled clay to a distance at least 30 feet above the uppermost coal bed and below the lowest workable coal bed. The purpose of this procedure is to protect the casing from corrosion, as well as to try to prevent gas or oil leakage.

Due to the irregularities of the drill hole and the difficulty of properly placing either the puddled clay or cement mortar in the narrow space between the casing and the drill hole, there has been considerable question in the minds of many persons as to the efficacy of this plan, and the later uncovering of drill holes where this plan had been used confirmed these doubts. (Reference is made to a paper by W. E. Fohl, appearing in the "Proceedings of the Engineers' Society of Western Pennsylvania," March, 1927.)

In the final report of the committee of the American Institute of Mining and Metallurgical Engineers, the following method of protecting the coal from contact with the gas or oil is recommended.

> Article III. Section 1. A well penetrating one or more workable coal beds shall be drilled to such a depth, and of such a size, as will permit the placing of casing and packers in the hole at such points, and in such manner, as will exclude all oil, gas, or gas pressure from the coal bed, except such as may be found in the local bed itself.
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> Each string of casing to be run in the hole shall be provided with a steel casing shoe or collar, to be firmly fixed on the bottom of the string of casing.

Each string of casing run through a workable coal bed shall be seated, at least thirty feet below said coal bed, in twenty feet of cement, mud, clay, or other nonporous material which will make an effective seal. After the first string of casing has been so seated, drilling may proceed to any required depth, and a second string, running through a workable coal bed, as well as succeeding strings, may be set in a similar manner.

Section 2. In the event that gas is found beneath a workable coal bed before the hole has been reduced from the size it had at the coal bed, a packer shall be placed below the coal bed, and the gas, by means of it, diverted to the inside of the adjacent string of casing through perforations made in said casing, and through it passed to the surface without contact with the coal bed. Should gas be found between two workable beds of coal, in a hole of the same diameter from bed to bed, two packers shall be placed with perforations in the casing between them, permitting the gas to pass to the surface inside the adjacent casing. In either of the cases here specified, the strings of casing shall extend from their seats to the surface at the top of the well.

Section 3. In the event that a well becomes productive of natural gas or petroleum, all coal-protecting strings of casing shall remain in place during the life of the well. During the life of the well the annular spaces between the various strings of casing adjacent to workable coal beds shall be kept open, and the tops of said casings shall be provided with casing heads, or other suitable devices, which will permit the free passage of gas, but prevent accidental or malicious filling of said annular spaces with dirt or debris.

Section 4. Should it be found necessary to drill a well through the horizon of a coal bed, mining operations being concluded and the coal removed, the hole shall be drilled at least thirty feet below the coal bed, of a size sufficient to permit the placing of a liner which shall start not less than twenty feet beneath the horizon of the coal bed and extend not less than twenty feet above it. Within this liner, which may be welded to the casing to be used, shall be centrally placed the largest sized casing to be used in the well, and the space between the liner and casing shall be filled with cement as they are lowered into the hole. Cement shall be placed in the bottom of the hole to a depth of twenty feet to form a sealed seat for both liner and casing. Beyond this point drilling shall proceed in the manner named in previous sections of this article.

Should it be necessary to drill through the horizon of two or more workable coal beds in which mining has been concluded and the coal removed, the liner as aforesaid shall be started not less than twenty feet below the lowest horizon penetrated and be extended to a point not less than twenty feet above the highest.

In a number of mining districts where little or no recovery of pillar coal is attempted it would be desirable to build a concrete or masonry pillar around the exposed liner of a well running through open workings, and to make the working places near the well more secure with rock-filled timber cribs. It would also be desirable to seal off the workings surrounding the well with good substantial masonry seals and to put down a drill hole, near the well, into the sealed area to act as a vent in case there should be a leak of gas from the well.

PLUGGING ABANDONED WELLS

Every oil or gas well should be properly plugged when abandoned - particularly where the well penetrates workable coal beds.

The report of the committee of 1913, published as U.S. Bureau of Mines Technical Paper 53, advocates that every abandoned oil or gas well be plugged and filled solidly, from bottom to top. It is recommended that the hole be filled with rock sediment, sand, or clay, or other suitable material, to form a hard and firm strata above the producing sand and below the inside string of casing. In this hard stratum three seasoned wood plugs, each 3 feet long and of a diameter equal to the diameter of the hole, should be driven into place. Then, at least 10 feet of clay should be tamped on top of the plugs. From the clay to the bottom of the next string of casing the hole should be filled with sand, rock sediment, or other suitable material, and then a plug driven in as described; this process should be repeated as each succeeding string of casing is pulled. The outer casing or casings that were put in through the coal seams, should be left in place and should be filled with clay, sand, or other suitable material.

The report of the committee of the American Institute of Mining and Metallurgical Engineers recommends the following method of plugging:

> It shall either be filled with mud, clay, or other nonporous material from the bottom of the well to a point twenty feet above the top of its lowest oil, gas, or water bearing stratum; or, a permanent bridge shall be anchored thirty feet below its lowest oil, gas, or water-bearing stratum, and from said bridge it shall be filled with mud, clay, or other nonporous material to a point twenty feet above said stratum; at this point there shall be placed a plug of cement, or other suitable material which will completely seal the hole, account being taken of the rock pressure to be confined. Between this sealing plug and a point twenty feet above the next higher oil, gas, or water bearing stratum, the hole shall either be filled, or bridged and filled, in the manner aforesaid; and at said point there shall be placed another plug of cement, or other suitable material which will completely seal the hole. In like manner the hole shall be filled and plugged, or bridged, filled and plugged with reference to each of its oil, gas, or water bearing strata. It is provided however, that where such strata are not widely separated, and are free from water, they may be grouped and treated as a single sand, gas or petroleum horizon, and the aforesaid filling and plugging be performed as though there had been but one horizon.
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> Where the well has penetrated one or more workable coal beds:
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> It shall be filled to, and securely plugged, in the manner aforesaid, at a point twenty feet above the top of the highest oil or gas-bearing stratum. From this point the hole shall be solidly filled to the surface with mud, clay, or other nonporous material; or it may be filled to the surface in the same manner, starting from a securely anchored bridge not less than forty feet below the lowest workable coal bed.
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> It is provided, however, that, if in the judgment of the Well Operator, the Coal Operator, and the State Mining Department, a permanent outlet to the surface is required, such outlet shall be provided in the following manner:
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> A plug of cement, or other suitable material, shall be placed in the well at a point not less than thirty feet below the lowest workable coal bed; in this plug and penetrating it, shall be securely fastened a two-inch pipe, without obstructions, which shall extend from the plug to a point ten feet above the surface, where it shall be provided with a "U"-shaped bend.

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> Following the setting of the cement plug and two-inch outlet pipe, as aforesaid, the hole shall be filled with cement to a point twenty feet above the lowest workable coal bed. From this point the hole shall be filled with mud, clay, or other nonporous material to a point thirty feet beneath the next overlying workable coal bed, if such there be, and the next succeeding fifty feet of the hole filled with cement. From the point last named the remainder of the hole shall be filled with mud, clay, or other nonporous material. Should there be more than two workable coal beds, each shall be protected, and the hole finally filled, in the manner heretofore described in this same paragraph.

This report also contains the following proviso with regard to mining:

> All coal mines operating in territory which is being simultaneously operated for the production of natural gas or petroleum shall be treated as gaseous mines, and shall be operated with all the known precautions against danger used in such mines; and these precautions shall be used as a safeguard against danger from wells, even though explosive gas is not liberated from the coal bed being worked.

The paragraph quoted above provides for the gas hazard in a mine in a territory where the coal and gas or oil are being extracted simultaneously. It is believed, however, that an even greater hazard exists where the oil or gas has been extracted as far as commercially feasible and the wells then abandoned without having been properly charted or plugged. Where these conditions exist, equal care should be exercised as regards gas hazards.

Any coal mine operating in a field where oil or gas wells have been drilled or are being drilled should take the utmost precautions against possible ignition of gas or oil. Among the most vital of these precautionary measures are the use of no electrical equipment but that of permissible type, use of none but permissible lights, and the maintenance of absolute control at all times over ventilating currents. Also such properties should be kept thoroughly rock-dusted throughout, and it is highly important that no blasting of any kind be done while the working shift is in the mine; when blasting of any kind is done it should be with permissible explosives fired electrically.

While without question every operator drilling oil or gas wells through workable coal beds should use the necessary precautions to prevent a seepage of the oil or gas into the coal beds or into the strata above or below them, yet it is hardly to be expected that he will go to the expense of doing so unless it is required of him by the terms of his lease, or by law; and since the lessor too often fails to realize the necessity of such precautions and to provide for them in the lease, the coal producing States should enact suitable laws to give this very necessary protection. Although the framing of these laws or regulations should have as their primary purpose the protection of the lives of those engaged in mining, on the other hand every precaution feasible should be taken to safeguard property rights, including not only those of the mine or prospective mine but also those of the persons involved in the drilling or ownership of oil or gas wells. Doubtless any law or regulation on this subject could best be administered through the State Mine Inspection Department, as is already being done in some of the leading coal mining States.

West Virginia has not only enacted a law governing the protection of oil and gas wells passing through workable coal beds, but has actually taken definite steps to enforce the law. That the coal operator is equally responsible with the oil or gas well operator for protection of the mines from inflow of oil and gas from wells passing through the coal bed being mined is well illustrated by the following letter to the coal-mine operators of that State:

August 28, 1929,
Charleston, W. Va.

TO ALL COAL OPERATORS:
Gentlemen:

The Department of Mines wishes to call your attention to Section 11 of the Oil Well Regulations, Chapter 86, Acts 1929.

The enclosed Instruction Sheet will assist you in preparing the maps referred to in this section and the data required by the Department. If your workings are within five hundred feet of any oil or gas well or any well being drilled for oil or gas, you should at once notify the Department of Mines, and the well operator of this fact and submit a map, such as is described on the enclosed sheet, together with such other data as is called for thereon, with such history of said well as may be available in order that the Department and the well operator may have the opportunity to approve or object to said plans as the case may be, and that plans may be agreed upon before the workings come within two hundred feet of said well.

Your attention is especially called to that portion of said Section 11, which makes it unlawful to remove any coal or other material or cut any passageway nearer than two hundred feet of any completed well or well that is being drilled, without the consent of the Department of Mines, etc.

Any coal operator who is now removing coal or other material within less than two hundred feet of any completed oil or gas well or well being drilled for oil or gas, must stop all mining operations within two hundred feet of said oil or gas well, or well being drilled for oil or gas until the plans for mining within two hundred feet of said well or drilling operations have been submitted to the well operator and the Department and have been approved by the Department and agreed to by the well operator.

It is necessary that you give the above your immediate attention. (See Section 14, Chapter 86, Acts 1929, for penalty for the violations of said Act.)

Yours very truly,

(SIGNED) R. M. LAMBIE,
Chief of Department of Mines.

Should the reader desire to make a more complete study of this very important subject, he is referred to the following publications, from which most of the data for this circular were obtained:

"Dangers from Oil and Gas Wells to Coal Mining Operations and Draft of a Model Law for Use of the Legislature of Any State Concerned." Final report of a committee of the American Institute of Mining and Metallurgical Engineers submitted April 27, 1928.

Fohl, W. E. Recovery of petroleum and natural gas through overlying coal beds. Proc. Eng. Soc. Western Pennsylvania, vol. 43, No. 2, March, 1927, pp. 119-131.

Hood, O. P., and Heggen, A. G. Proposed regulations for the drilling of gas and oil wells. Tech. Paper 53, U. S. Bureau of Mines, 1913, 28 pp.

"Oil and Gas Well Regulations of the State of West Virginia," enacted February 14, 1929. Mining Law of the State of West Virginia as amended by the legislature in regular session, 1929. Compiled by R. M. Lambie, Chief of Department of Mines.

Rice, G. S. Safety in coal mining (a handbook). Bull. 277, U. S. Bureau of Mines, 1928, 141 pp.

Rice, G. S., Hood, O. P., and others. Oil and gas wells through workable coal beds; papers and discussions. Bull. 65, U. S. Bureau of Mines, 1913, 101 pp.